2012 Project X Physics Study

Large Area Picosecond Photo-Detectors

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THE UNIVERSITY OF CHICAGO

on behalf of the LAPPD collaboration

- *Introduction*
- *LAPPD status*
- *Conclusions*

June 16, 2012

Large Area Picosecond Photo Detectors (LAPPD)

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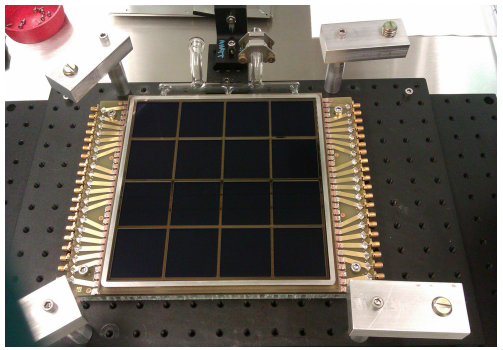

Goals:

- *Large area*
- *Picosecond timing*
- *Cheap*

Applications:

- **Picoseconds on large area**
- *Neutrinos*
- *Kaons*
- *Collider*
- *Muon cooling*
- *PET scan*
- *X-ray*
- *Neutrons*

Super Module

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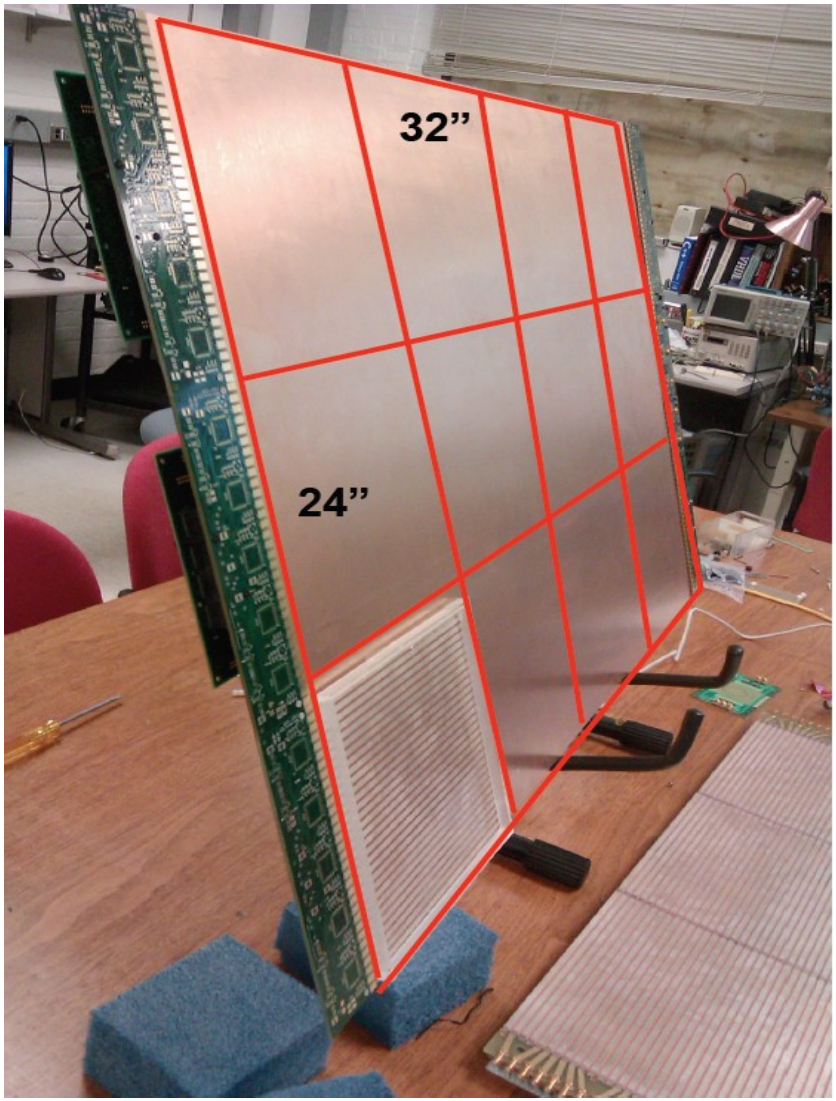
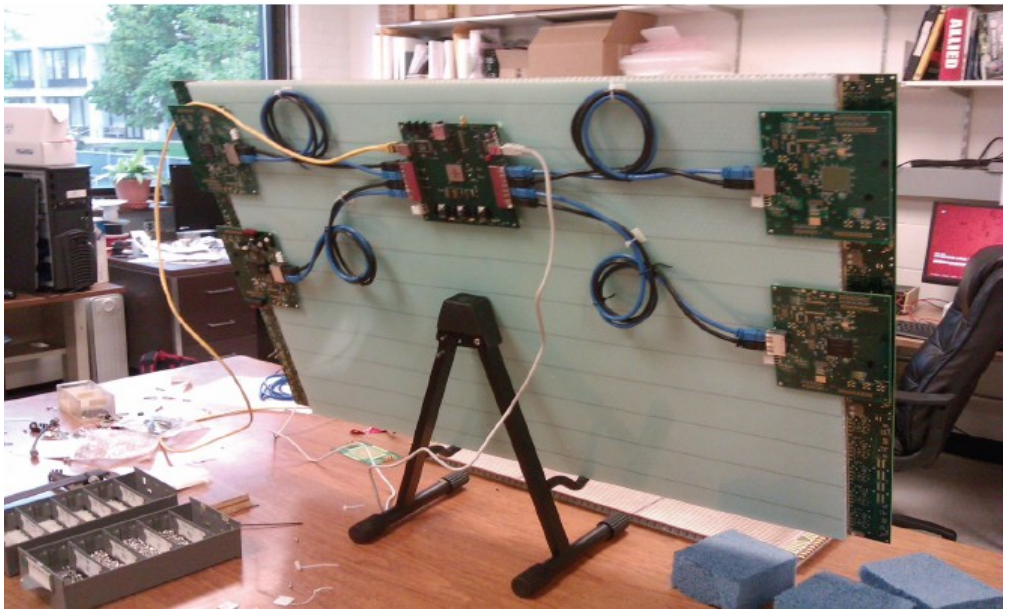


- ***Thin* planar glass body detector**
- ***MCPs share single delay line anode***
- ***Fully integrated electronics***



Non-Cryogenic Liquid Detector

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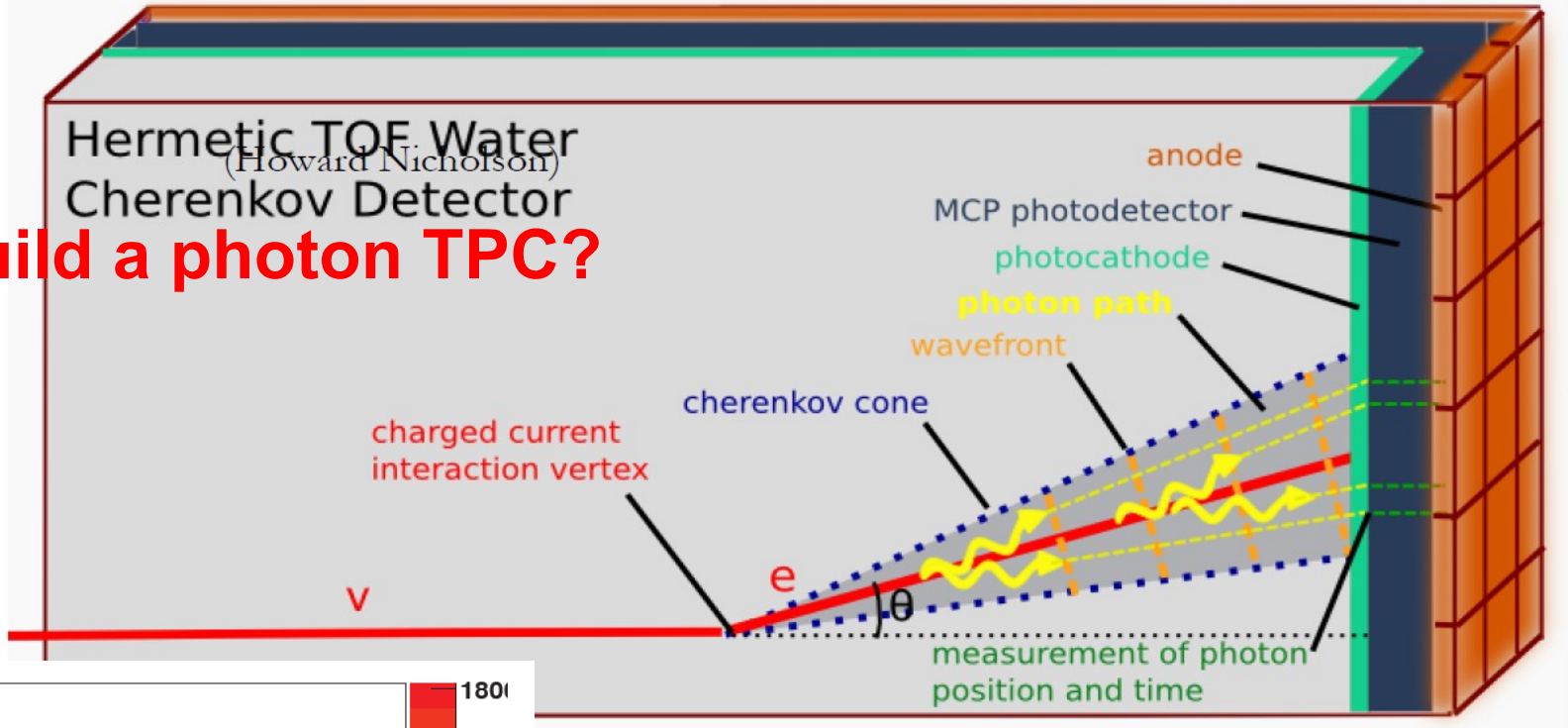
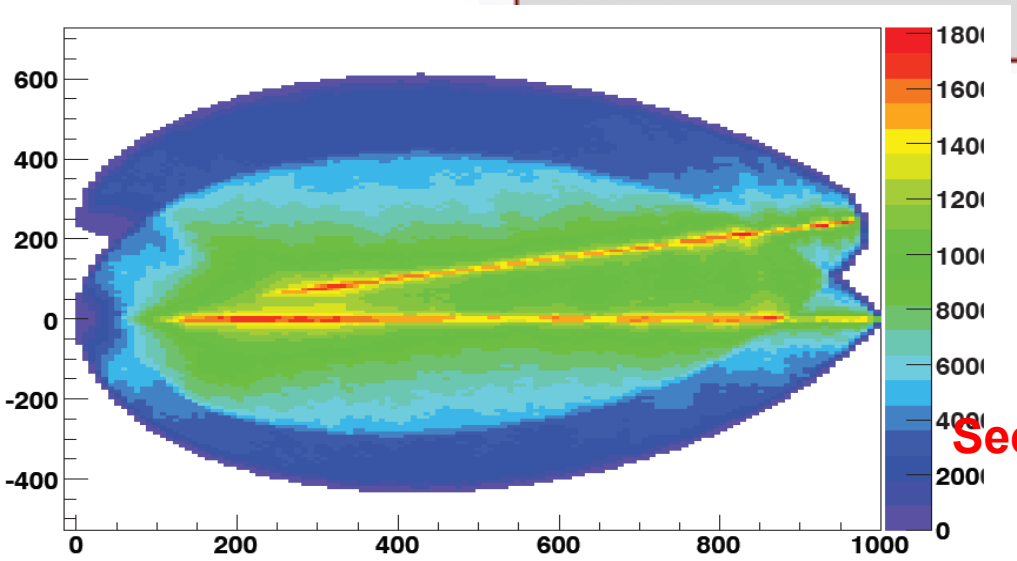


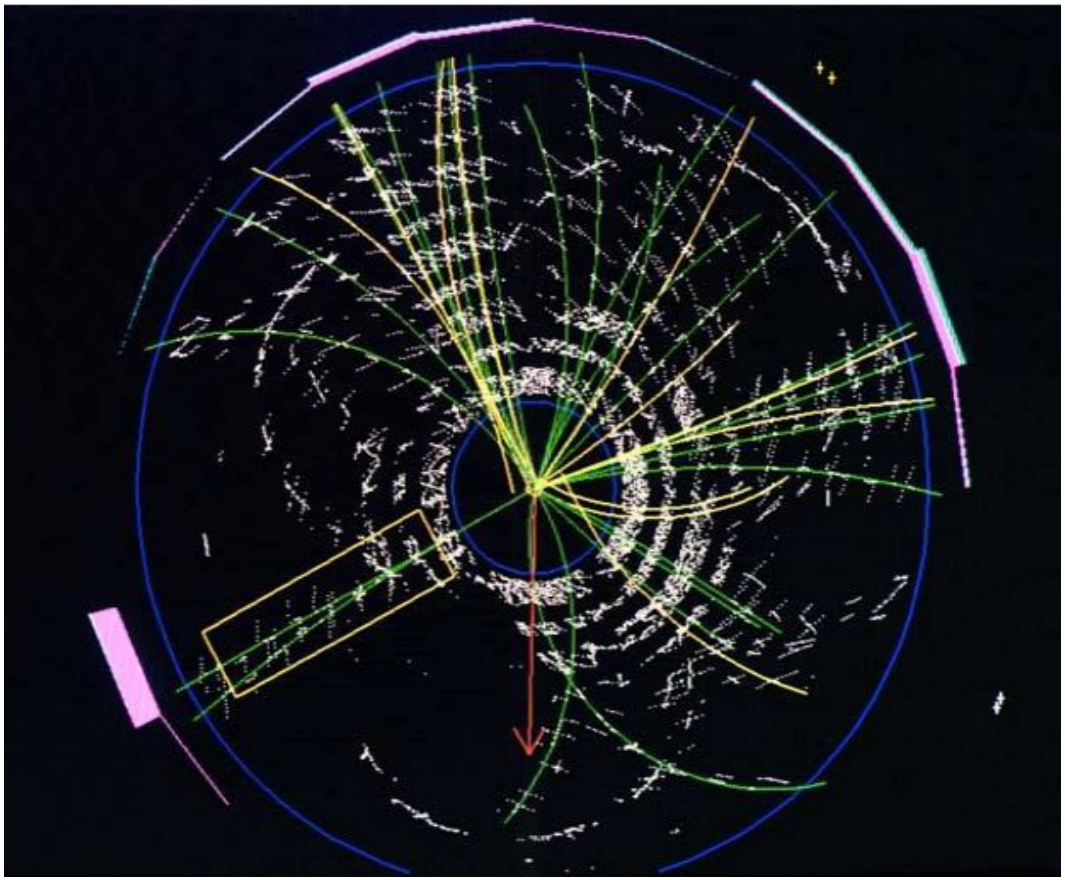
Can we build a photon TPC?



See Matt Wetstein talk on Monday

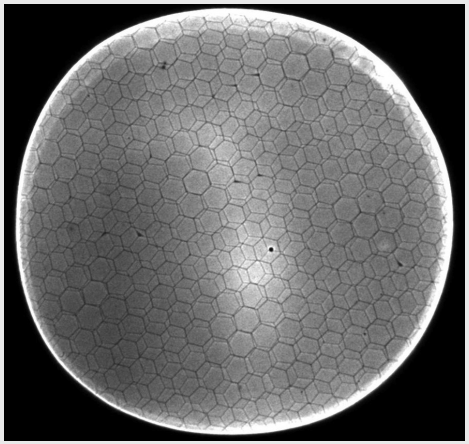
Particle Identification

Can we start talking about particles instead of jets?



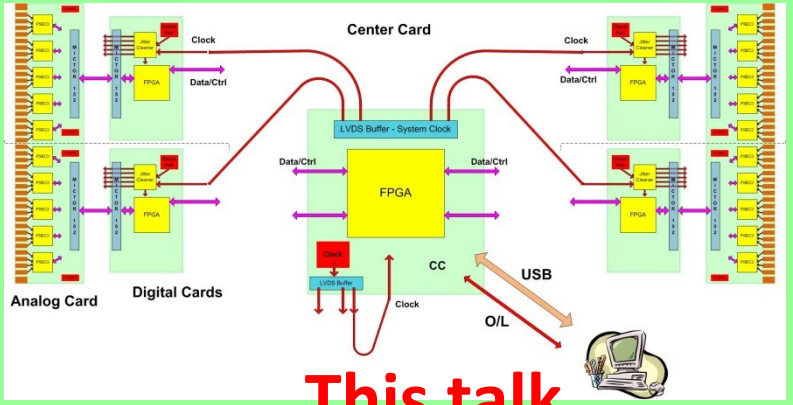
LAPPD components

MicroChannel Plates



This talk

Electronics/Integration



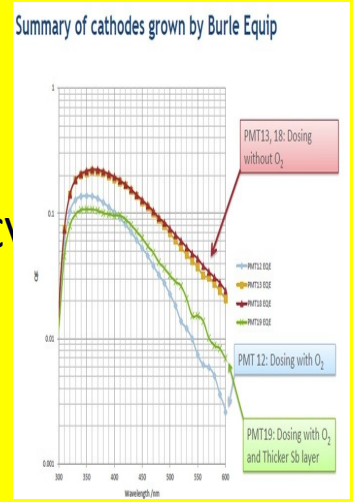
This talk

Hermetic Packaging

This talk

Photocathodes

CV



Next talk

MCP fundamentals

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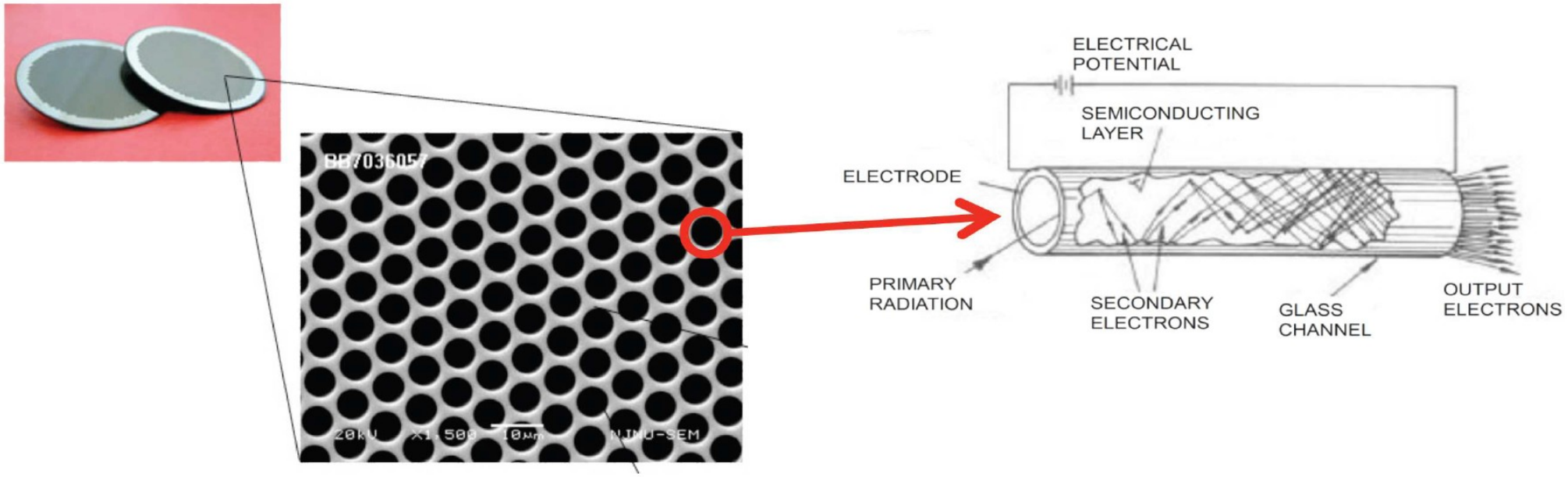

Many electron multipliers per unit area

- Glass substrate with micron pores
- Each pore acts as an electron multiplier
  - *secondary electron emission (SEE)*
  - *high voltage applied*
- Usually very expensive

Commercial MCP vs LAPPD MCP

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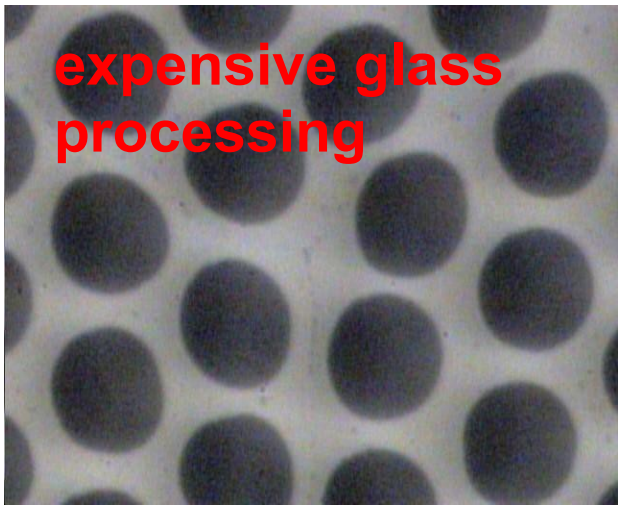
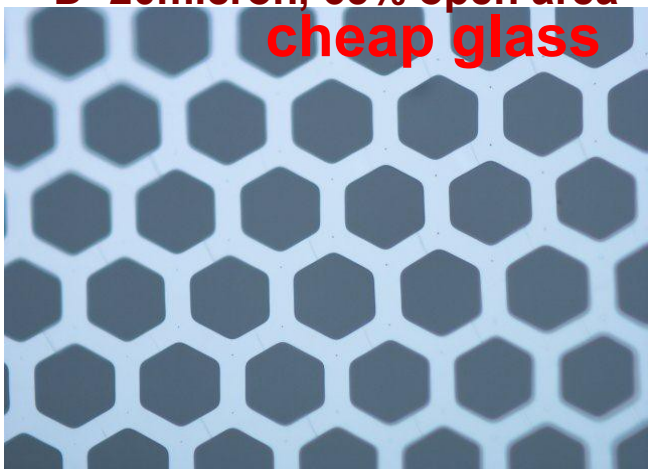
Conventional Pb-glass MCP



Incom glass substrate

D~20micron, 65% open area



Three functions in one glass plate

- *Pores*
- *Resistive layer to provide electric field in the pore*
- *Pb-oxide layer serves as SEE layer*

Separate the three functions

- *Pores (L/D~60)*
- *Resistive layer applied using Atomic layer deposition (ALD)*
- *SEE layer applied using ALD*

MCP by Atomic Layer Deposition (ALD)

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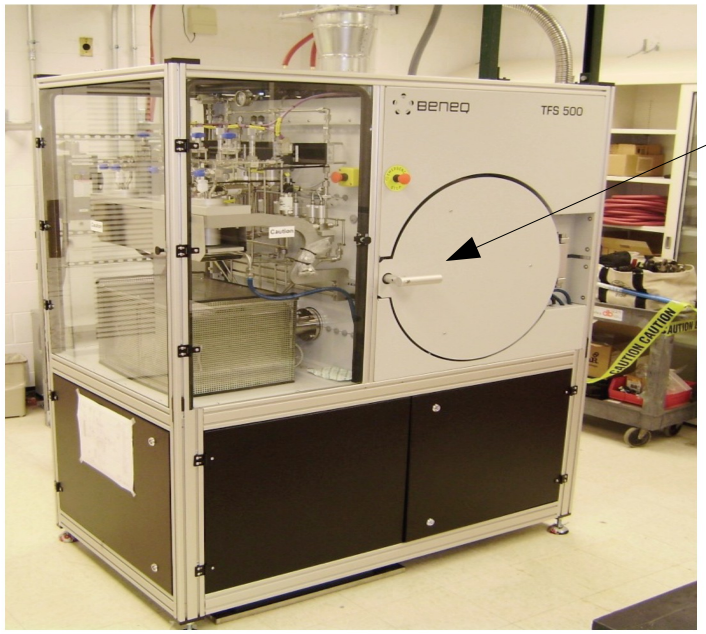
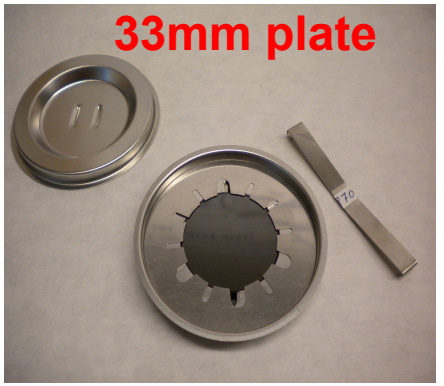
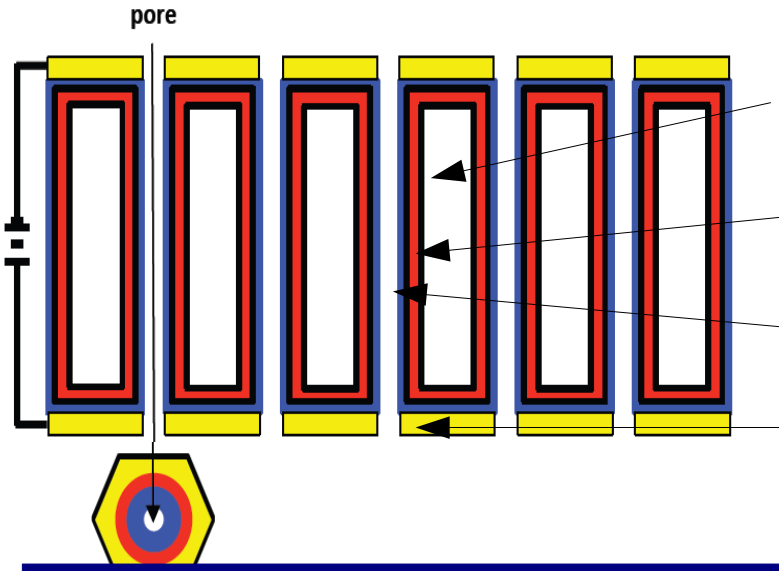


Beneq reactor for ALD
@Argonne National Laboratory



Wide parameter space:
- **relative composition of materials**
- **temperature**
- **different materials and thickness**

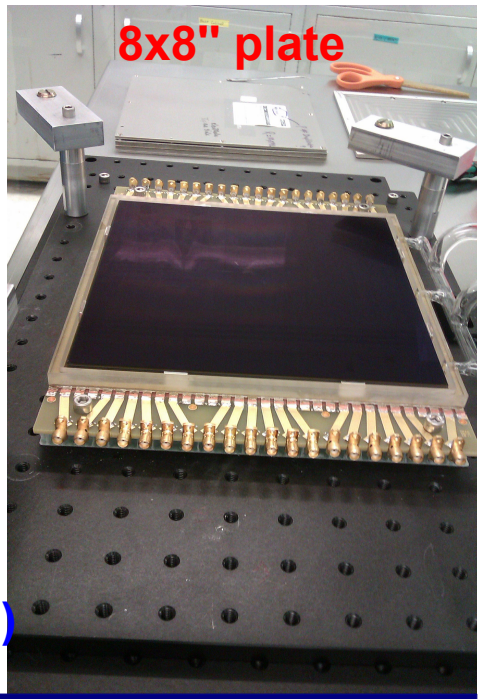


Porous glass

Resistive coating ~100nm (ALD)

Emissive coating ~ 20nm (ALD)

Conductive coating (thermal evaporation or sputtering)



LAPPD vertical slice

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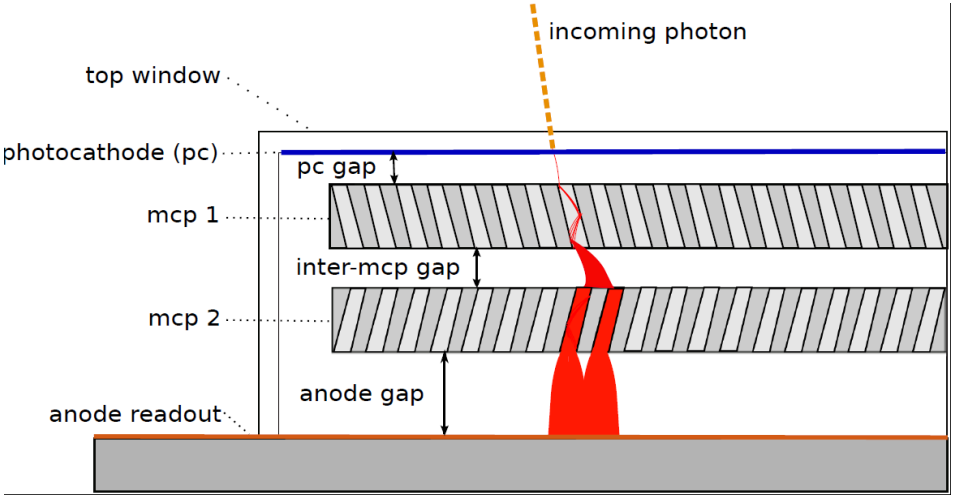
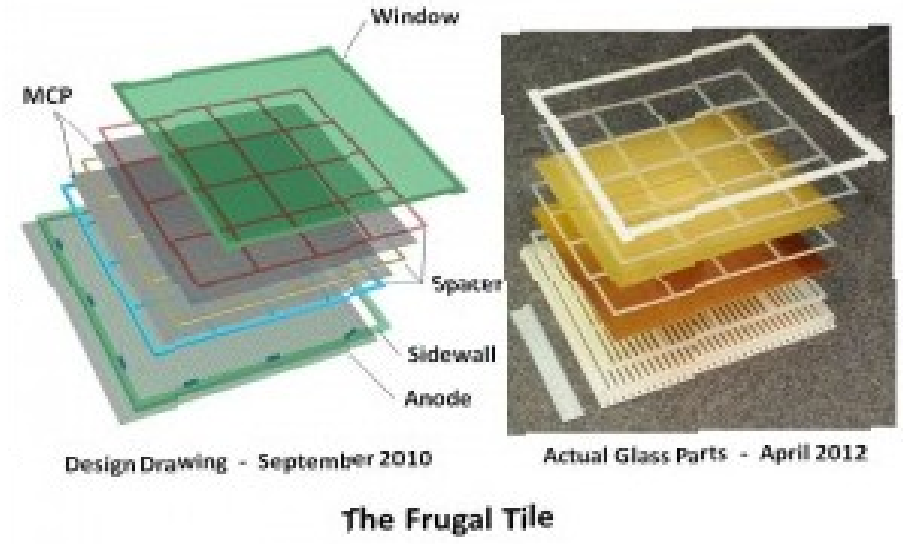
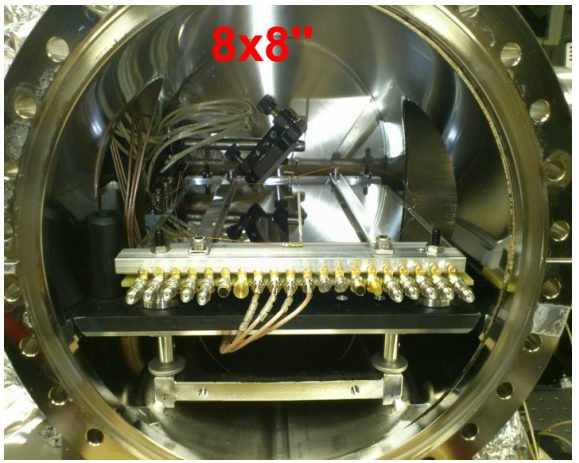
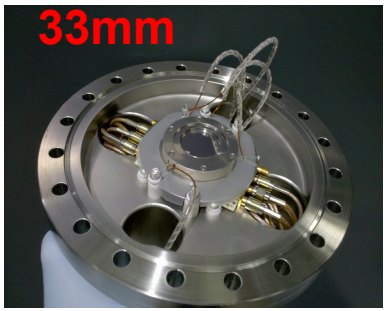


- Enclosed in vacuum (10^{-7} – 10^{-8} torr)
- Photocathode (aluminum at the moment; low quantum efficiency is compensated by high UV light intensity)
- Stack of MCP plates
  - Chevron geometry (8° bias angle)
  - ~1kV across each MCP
  - ~200V acros gaps
- Anode (delay line 1.6 GHz bandwidth)
- Readout with high bandwitdth scope or LAPPD made DAQ





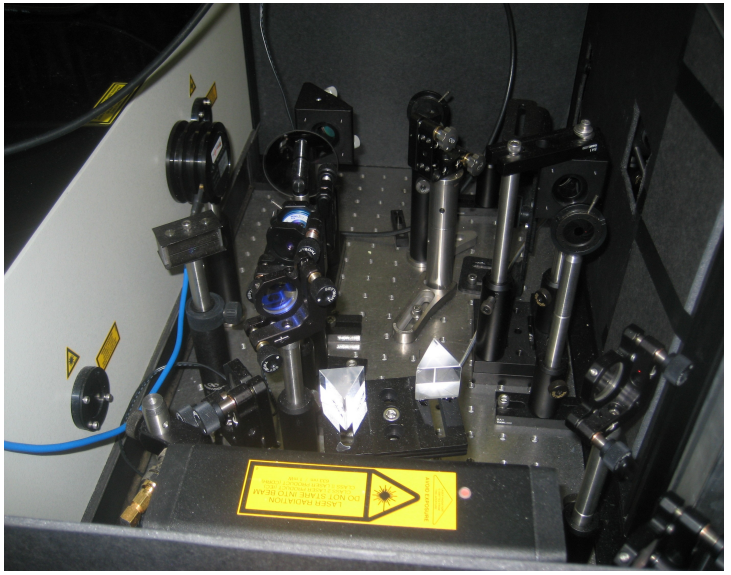


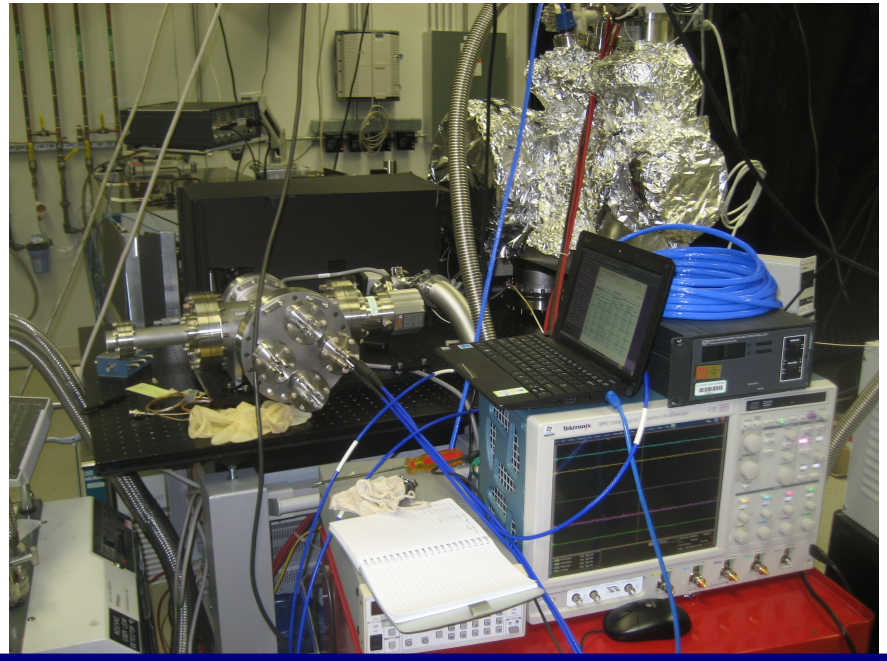
Laser Testing Setup

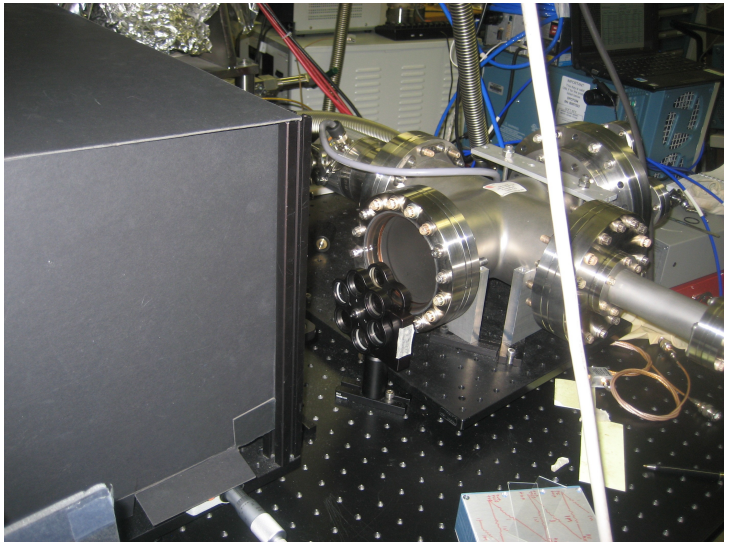
@ Advanced Photon Source Division (APS) Argonne National Laboratory

Sub-picosecond laser

- Ti:Sapph 800nm; power ~800 mW
- pulse duaration O(10) femtoseconds
- 1KHz repetion rate
- Non-linear optics to produce
- 266nm UV light







Gain with the MCP stack

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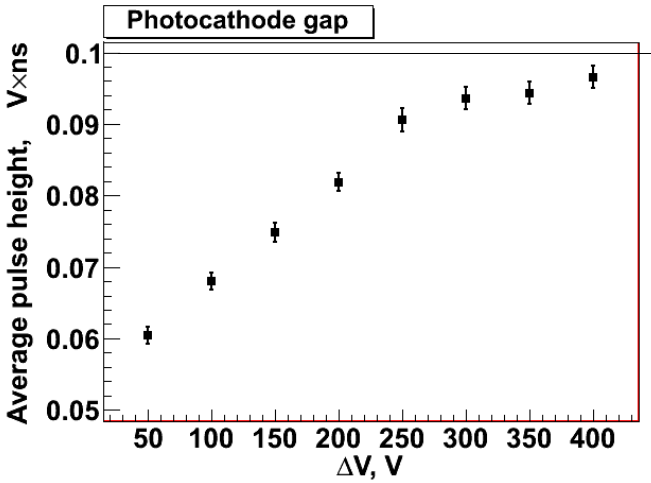
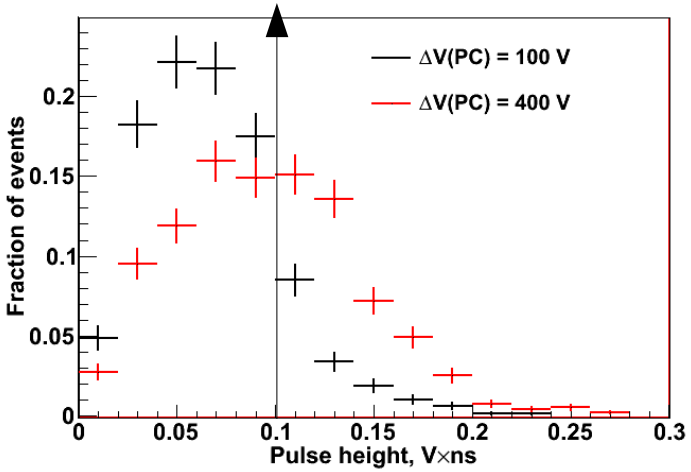
pair of 40 MOhm 33mm MgO plates

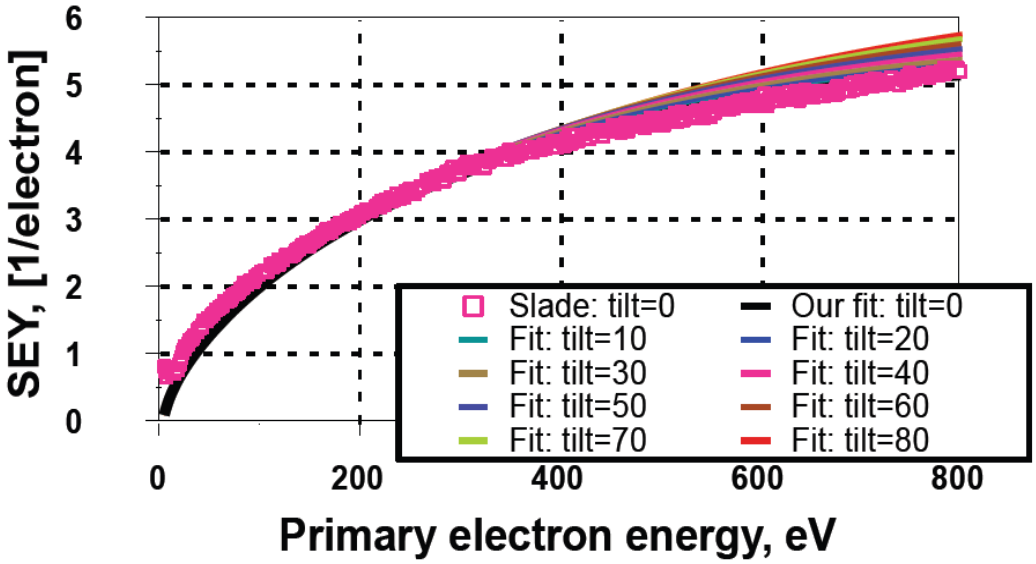


~2x10^7 electrons out

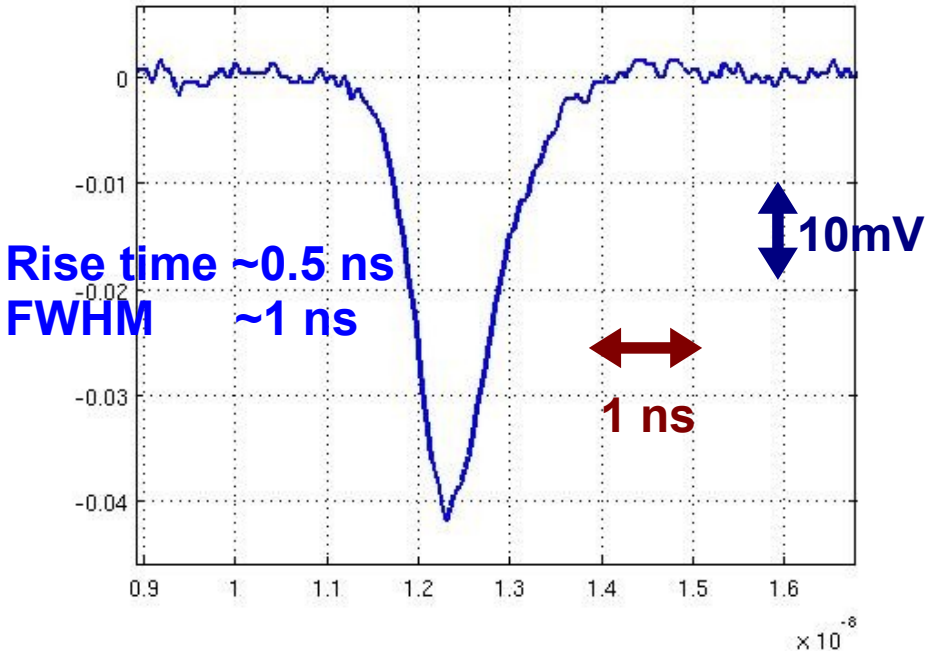
~2x10^7 electrons out



20 nm MgO SEY data



MCP pulses and timing



Timing analysis approach

- Fit rising edge
- Use constant fraction discriminant

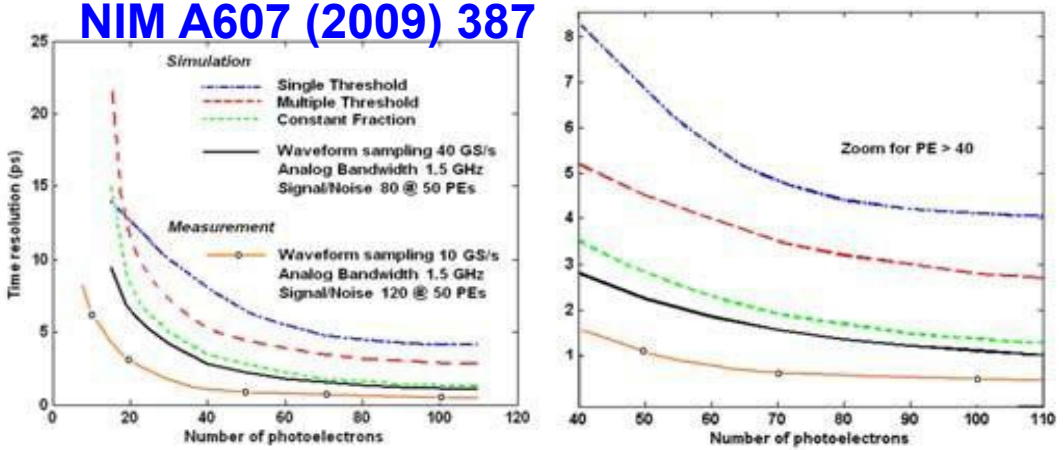
Questions

- Time resolution
- Position resolution

Time resolution determinants:

1) Signal to noise
2) Analog Bandwidth
3) Sampling rate
4) Signal statistics

NIM A607 (2009) 387



Time and positon resolution

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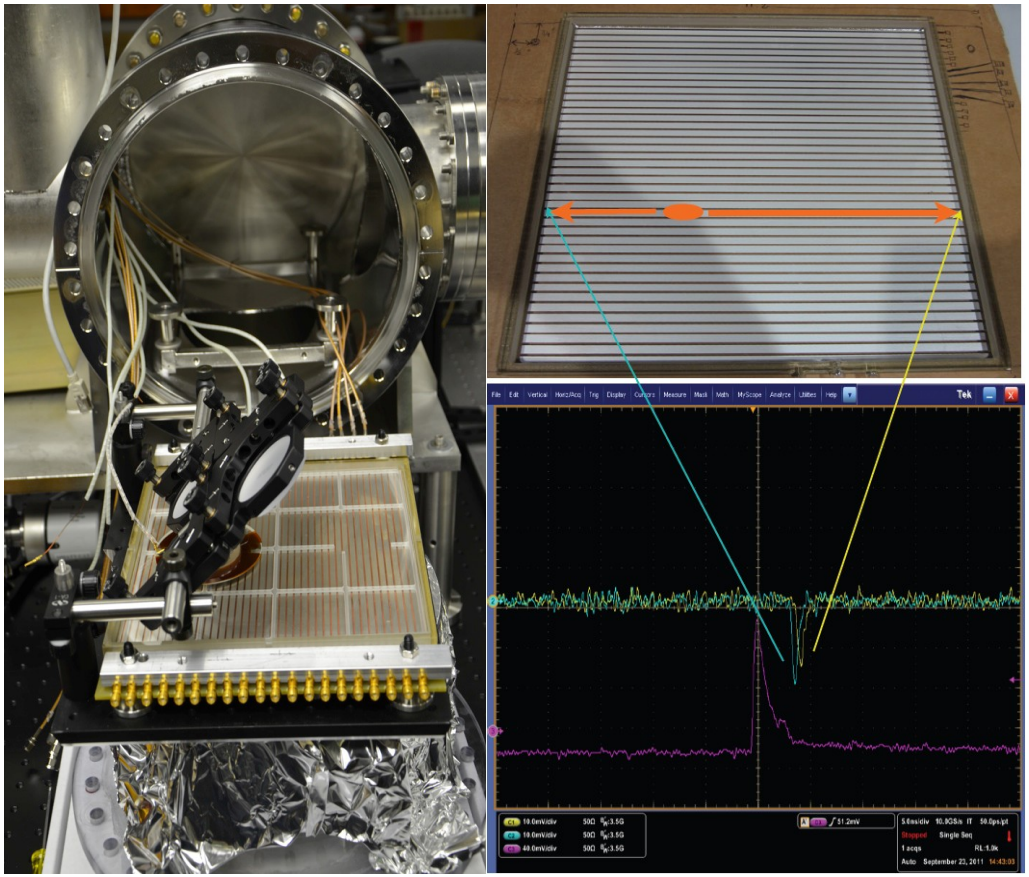
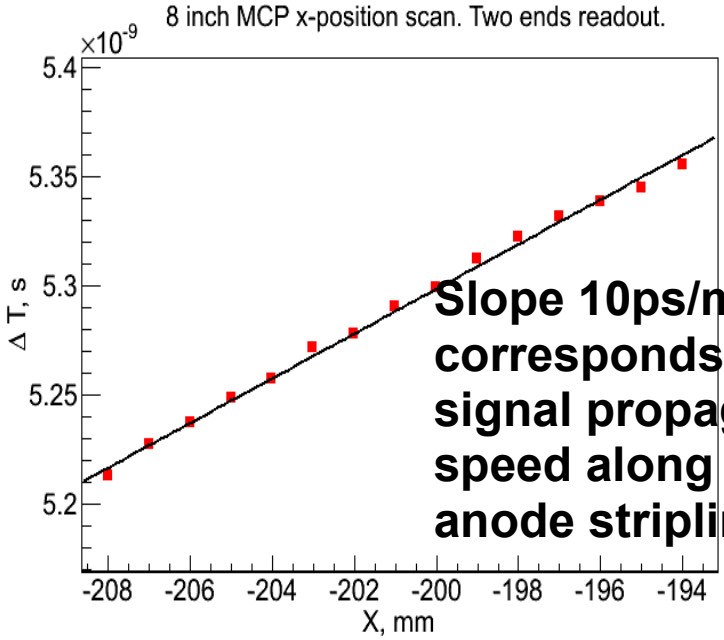
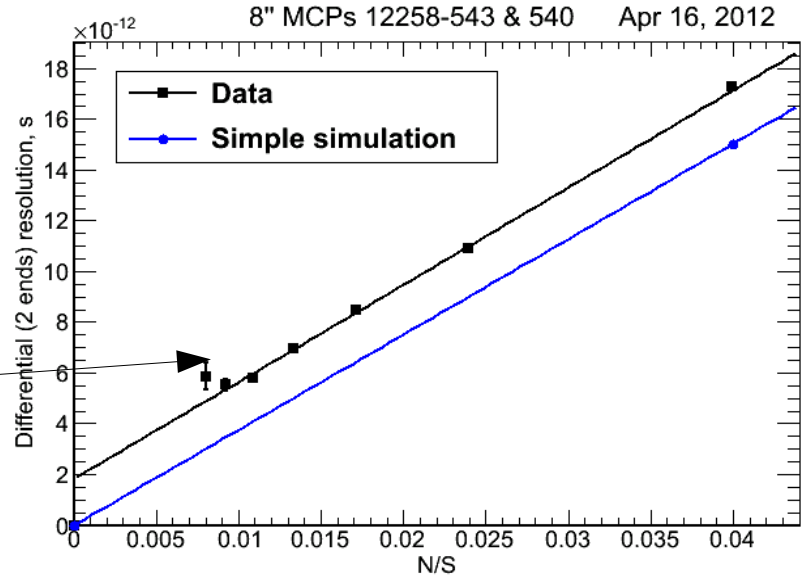




Slope 10ps/mm corresponds to 2/3c signal propagation speed along the anode stripline



6 ps in ΔT → 0.6 mm in ΔX

See Monday talk at TOF section for more info

Hermetic packaging

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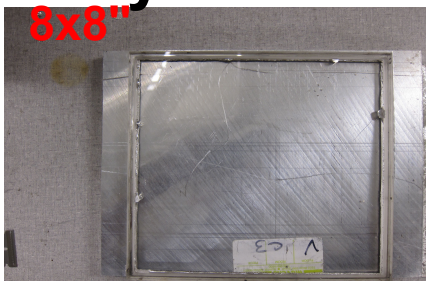
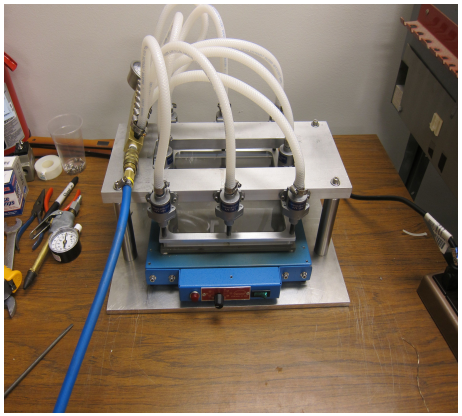
1) Glass sidewall over the anode plane: solved by frit sealing
2) Top window over the full vertical slice: work in progress

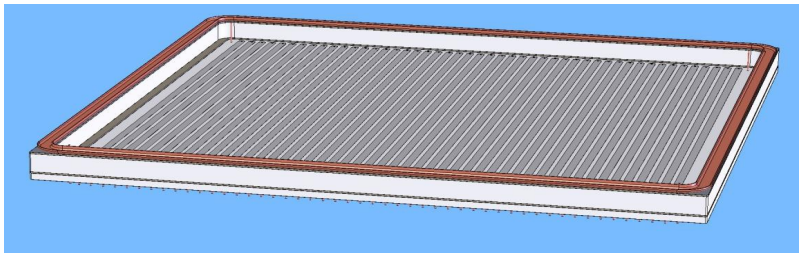
Primary path for the top seal: indium seal

ANL & UChicago effort glass body



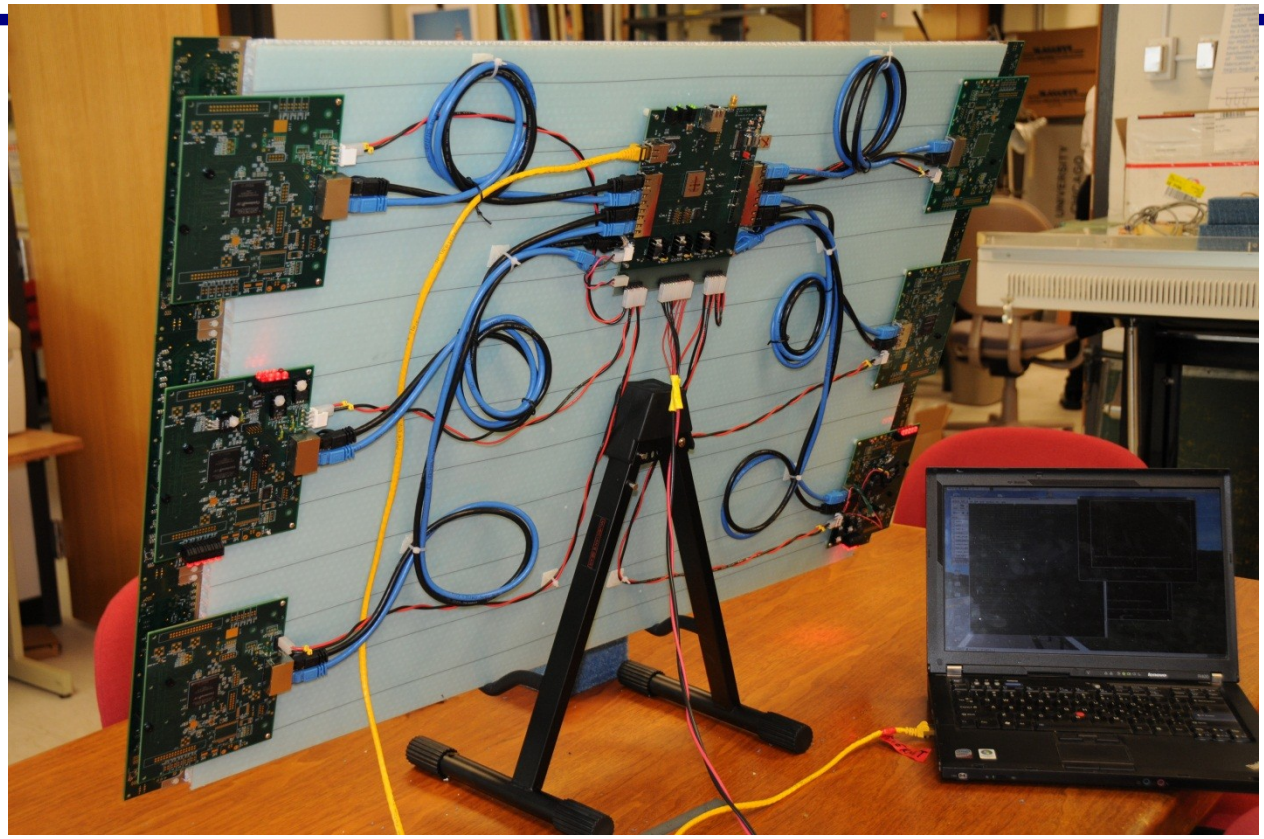


Production Facility at SSL/UCB ceramic body



Parallel path: learn from industry (there are plenty vacuum sealed products around)

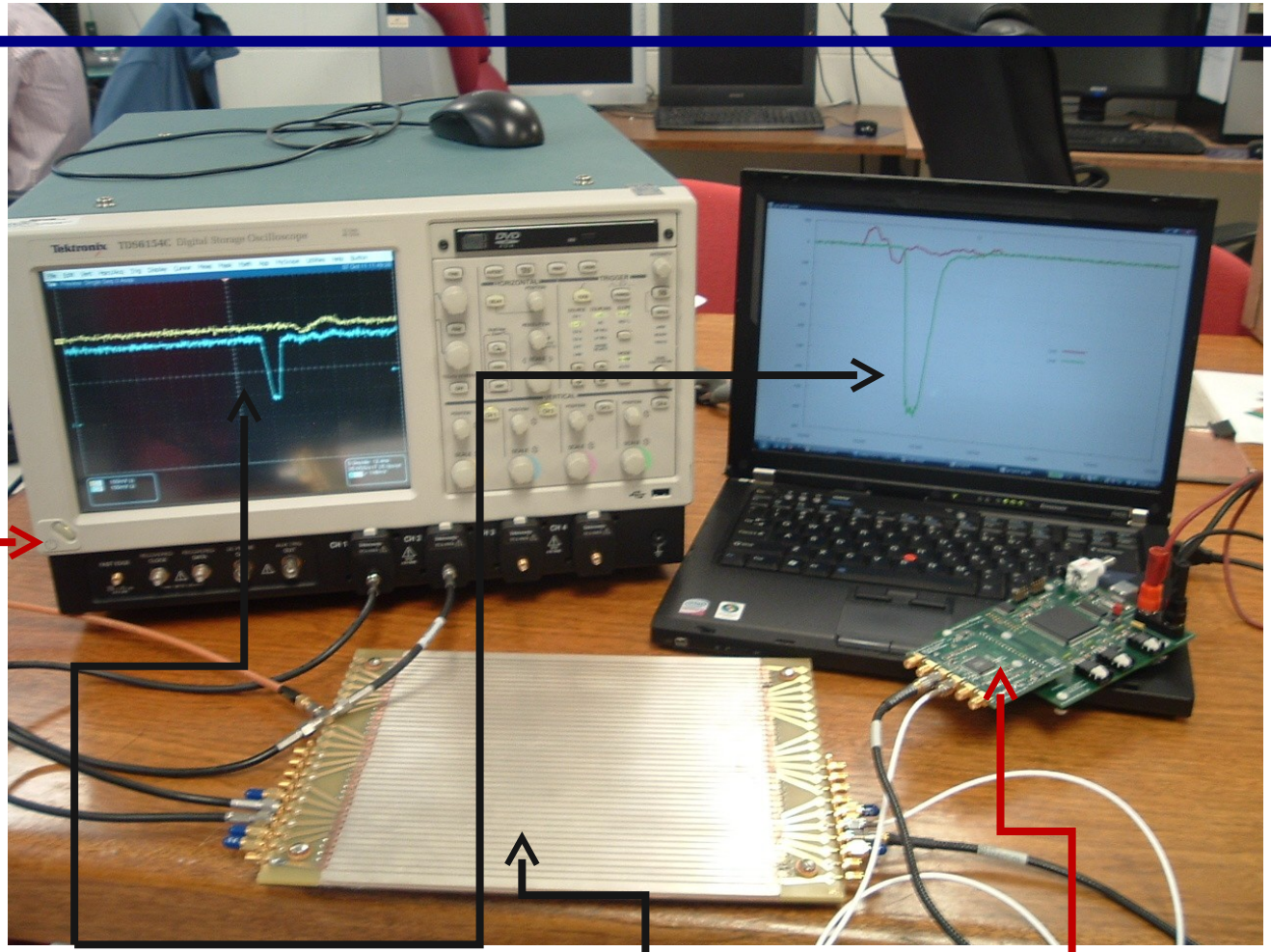
Electronics



- Analog card (PSEC4 chip) for every 6 channels:
  - waveform sampling
- Digital card (FPGA) for every 5 chips (30 channels):
  - charge, time, shape
- Central card (FPGA) 1 per supermodule:
  - time and position; system control, CPU interface

Scope-on-a-chip

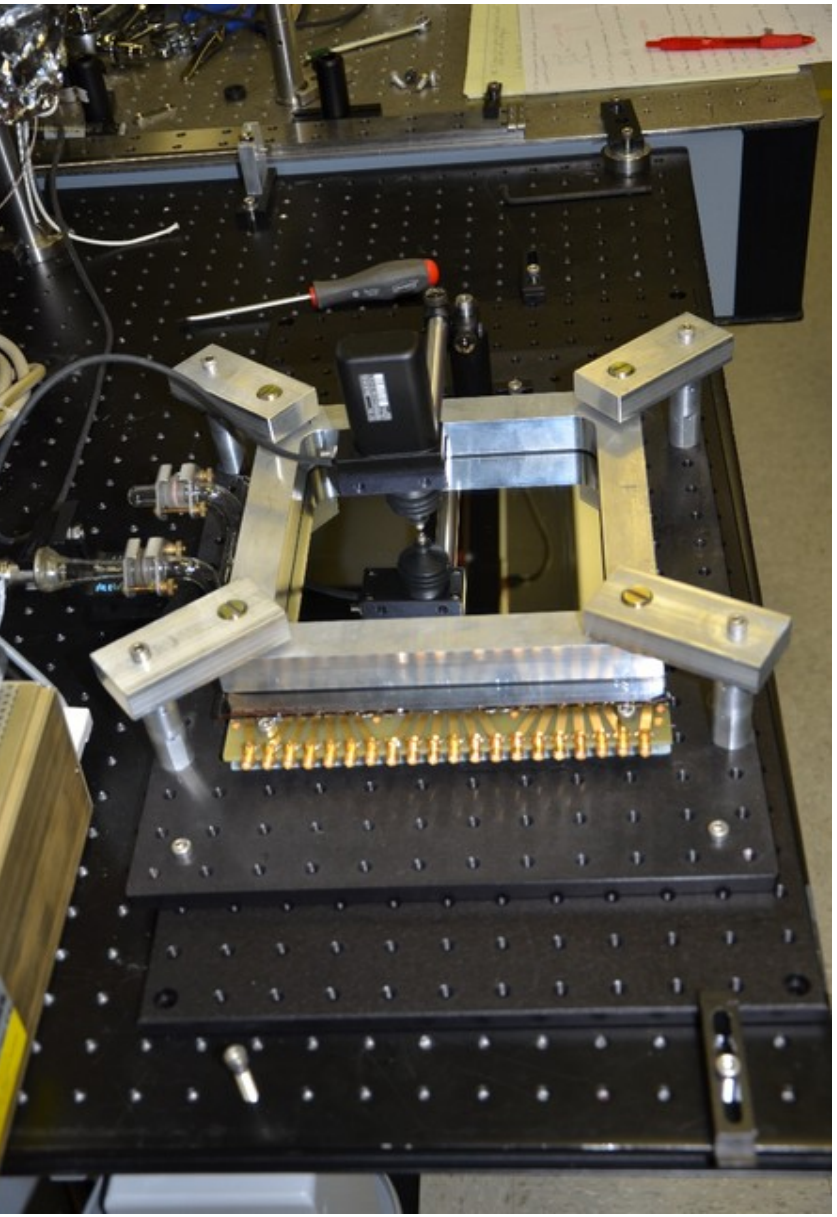
Designed by Eric Oberla (UC grad student)



20 GS/scope
4-channels (142K$)

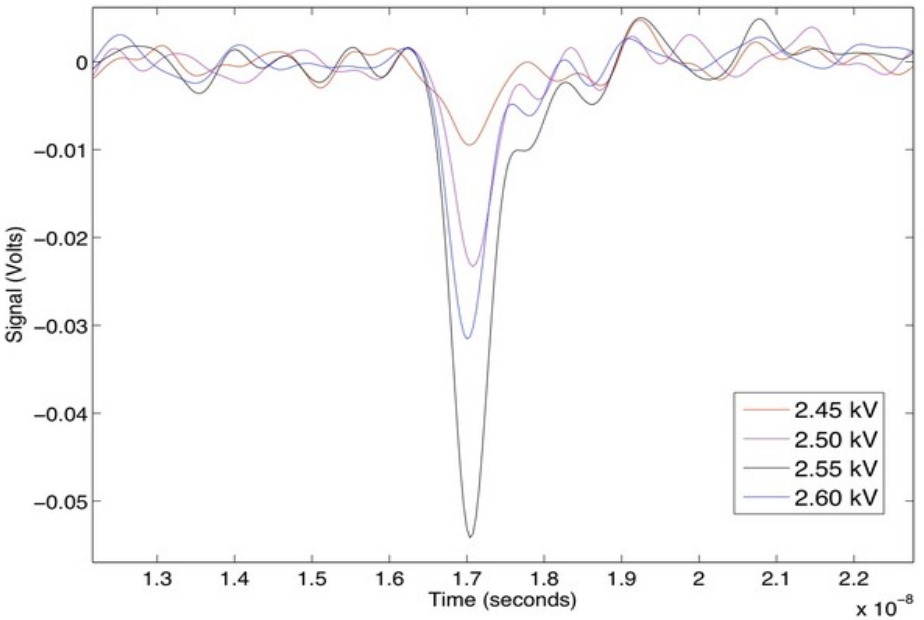
17 GS/PSEC-4 chip
6-channels ($130 ?!)

Demountable



„Sealed tube“ prototype
- full vertical slice
- data taking using LAPPD made electronics

What's different from final design
- active pumping
- aluminun photo-cathode



Conclusions and Outlook

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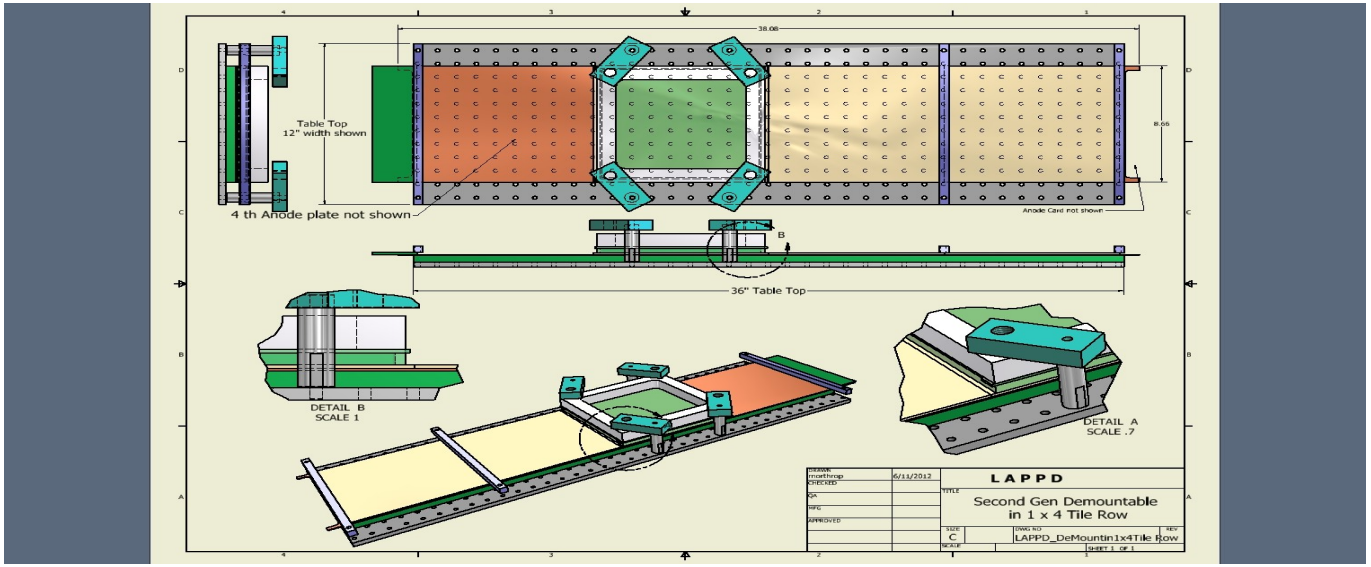
- Approaching picosecond domain on large area
- Demountable prototype shows very promissing performance
- Major challenges: photo-cathode & top seal
- Next steps:
  - many... photo-cathode and top seal are crucial
  - testing of the super-module with fully integrated DAQ
  - see our plans and progress here

http://psec.uchicago.edu/ and http://psec.uchicago.edu/blogs/lappd/



Back-up

Project X

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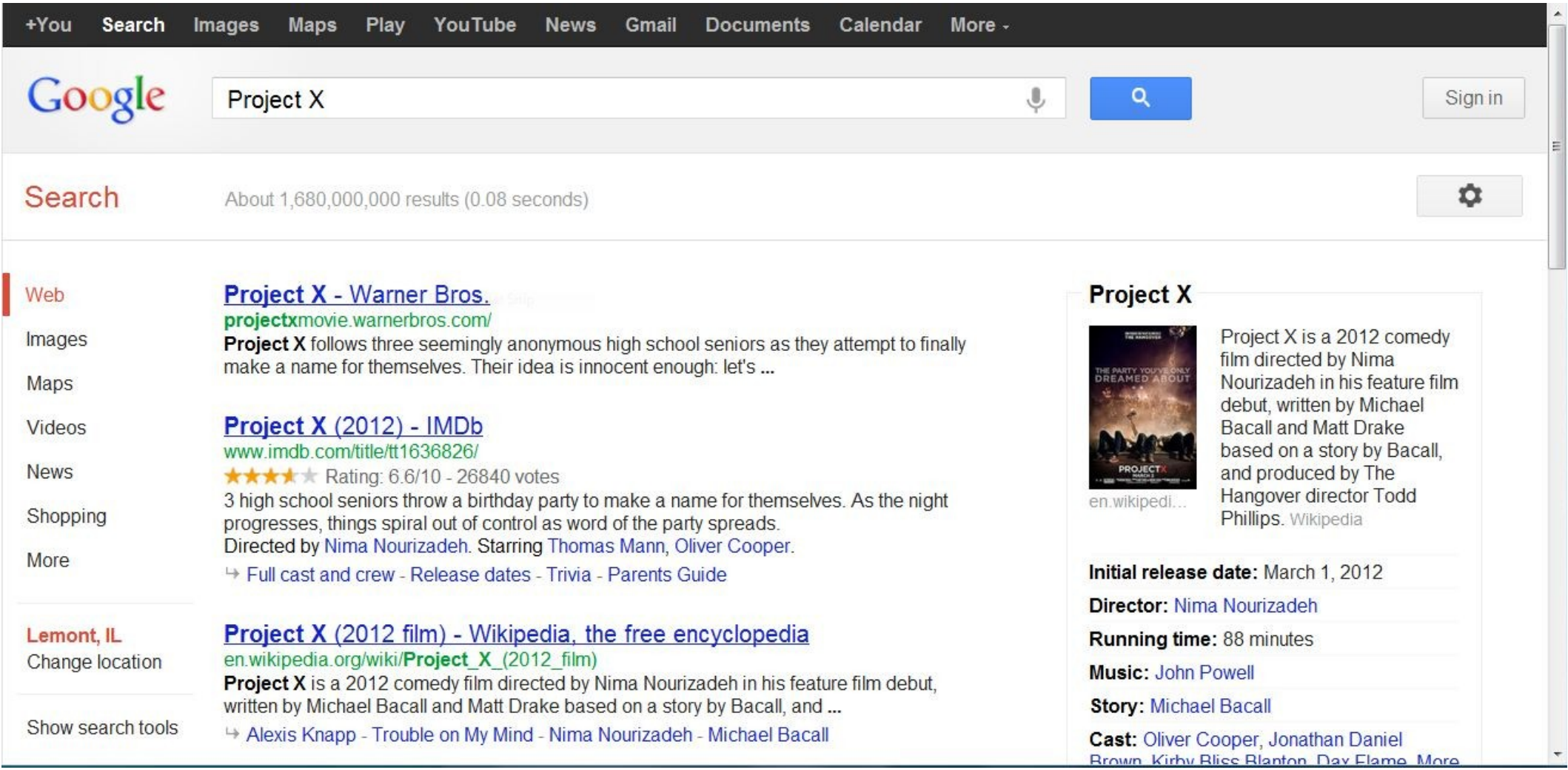

Named Projects (large and not so)

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